Physics 311

Homework Set 9

1. A particle of charge q enters a region of uniform magnetic field $\vec{B}$ (pointing *out* of the page). The field deflects the particle of distance d above the original line of flight, as shown in Fig. 5.8.

   a) Is the charge positive or negative?

   b) In terms of a, d, B, and q, find the velocity of the particle.

2. In 1897 J. J. Thomson "discovered" the electron by measuring the charge-to-mass ratio of streams of electrons, with charge q and mass m as follows:

   a) First he passed the beam through the uniform crossed electric and magnetic fields $\vec{E}$ and $\vec{B}$ (mutually perpendicular, and both of them perpendicular to the beam), and adjusted the electric field until he got zero deflection. What, then, was the speed of the particles (in terms of E and B)?

   b) Then he turned off the electric field, and measured the radius of curvature, R, of the beam, as deflected by the magnetic field alone. In terms of E, B, and R, what is the charge-to-mass ratio (q/m) of the particles?

3. Suppose that the magnetic field in some region has the form

$$\vec{B} = ky\,\hat{z} \tag{1}$$

   (where k is a constant). Find the force on a square loop (side b), lying in the xy plane and centered at the origin, if it carries a current I, flowing counterclockwise, when you look down the z axis.

4. A current I flows down a wire of radius b.

   a) If it is uniformly distributed over the surface, what is the surface current density K?

   b) If it is distributed in such a way that the volume current density is inversely proportional to the distance from the axis, what is the total current in the wire?

5. a) A phonograph record carries a uniform density of "static electricity" σ. If it rotates at angular velocity ω, what is the surface current density K at a distance r from the center?

   b) A uniformly charged solid sphere, of radius R and total charge Q, is centered at the origin and spinning at a constant angular velocity ω about the z axis. Find the current density $\vec{J}$ at any point $(r,\ \theta,\ \phi)$ within the sphere.